

1 What is claimed is:

2
3 1. A method of recovery in an asynchronous remote copy system having a
4 primary file system at a primary site and a secondary file system at a secondary site, said
5 method comprising:

6 in response to the primary site becoming inoperative during read/write access to
7 the primary file system and asynchronous remote copy of changes made to the primary
8 file system being copied to the secondary file system, beginning read/write access to the
9 secondary file system, making a snapshot copy of the secondary file system at the
10 beginning of read/write access to the secondary file system, and keeping a record of
11 changes made to the secondary file system during the read/write access to the secondary
12 file system; and thereafter,

13 when the primary site becomes operative, using the snapshot copy to restore the
14 primary file system to the state of the secondary file system existing when read/write
15 access of the secondary file system was begun, and then writing into the primary file
16 system the changes made to the secondary file system during the read/write access to the
17 secondary file system; and

18 terminating read/write access to the secondary file system, and once the changes
19 made to the secondary file system have been written into the primary file system,
20 restarting read/write access to the primary file system and asynchronous remote copy of
21 changes made to the primary file system being copied to the secondary file system.

1 2. The method as claimed in claim 1, wherein the asynchronous remote copy
2 of changes made to the primary file system being copied to the secondary file system
3 includes using the Internet Protocol to transmit the changes made to the primary file
4 system over a data network between the primary site and the secondary site.

5
6 3. The method as claimed in claim 2, which includes, in response to the
7 primary site becoming operative, transmitting over a first IP pipe changes having been
8 made to the secondary file system during the read/write access to the secondary file
9 system prior to the primary site becoming operative, and concurrently transmitting over a
10 second IP pipe changes having been made to the secondary file system during read/write
11 access to the secondary file system after the primary site becomes operative.

12
13 4. The method as claimed in claim 1, wherein the state of the secondary file
14 system existing when read/write access of the secondary file system was begun is a prior
15 state of the primary file system existing before the primary site became inoperative, and
16 the method includes the primary site keeping a list of blocks that have been changed in
17 the primary file system during read/write access to the primary file system, and the
18 snapshot copy is used to restore the primary file system to the state of the secondary file
19 system existing when read/write access of the secondary file system was begun by
20 accessing the list of blocks that have been changed in the primary file system during the
21 read/write access to the primary file system to determine the blocks that have been
22 changed in the primary file system since said prior state of the primary file system, and

1 copying from the snapshot copy to the primary file system the blocks that have been
2 changed in the primary file system since said prior state of the primary file system.

3
4 5. A method of recovery in an asynchronous remote copy system having a
5 primary file system at a primary site and a secondary file system at a secondary site, said
6 method comprising:

7 in response to the primary site becoming inoperative during the asynchronous
8 remote copy of changes made to the primary file system being copied to the secondary
9 file system, beginning read/write access to the secondary file system, and then:

10 in response to the primary site becoming operative, synchronizing the primary file
11 system to the secondary file system by beginning asynchronous remote copy of changes
12 made to the secondary file system being copied to the primary file system, making a
13 snapshot copy of the secondary file system at the beginning of the asynchronous remote
14 copy of changes made to the secondary file system being copied to the primary file
15 system, synchronizing the primary file system to the snapshot copy of the secondary file
16 system, and once the primary file system has been synchronized to the snapshot copy of
17 the secondary file system, terminating read/write access to the secondary file system and
18 completing the asynchronous remote copy of changes made to the secondary file system
19 being copied to the primary file system; and

20 once the asynchronous remote copy of changes made to the secondary file system
21 has been completed, restarting the read/write access to the primary file system and
22 asynchronous remote copy of changes made to the primary file system being copied to
23 the secondary file system.

1
2 6. The method as claimed in claim 5, wherein the asynchronous remote copy
3 of changes made to the primary file system being copied to the secondary file system
4 includes using the Internet Protocol to transmit the changes made to the primary file
5 system over a data network between the primary site and the secondary site.

6
7 7. The method as claimed in claim 5, wherein the asynchronous remote copy
8 of changes made to the secondary file system being copied to the primary file system
9 includes transmitting changes made to the secondary file system over a first IP pipe from
10 the secondary site to the primary site, and the synchronizing of the primary file system to
11 the snapshot copy of the secondary file system includes transmitting changes made to the
12 secondary file system over a second IP pipe from the secondary site to the primary site,
13 and wherein the transmission of the changes made to the secondary file system over the
14 first IP pipe is concurrent with the transmission of the changes made to the secondary file
15 system over the second IP pipe.

16
17 8. A method of recovery in an asynchronous remote copy system having a
18 primary file system at a primary site and a secondary file system at a secondary site, said
19 method comprising:

20 in response to the primary site becoming inoperative during read/write access to
21 the primary file system and asynchronous remote copy of changes made to the primary
22 file system being copied to the secondary file system, beginning read/write access to the
23 secondary file system, making a first snapshot copy of the secondary file system at the

1 beginning of read/write access to the secondary file system, and keeping a record of
2 changes made to the secondary file system during the read/write access to the secondary
3 file system; and thereafter,

4 when the primary site becomes operative, making a second snapshot copy of the
5 secondary file system, beginning asynchronous remote copy of changes made to the
6 secondary file system since the second snapshot copy being copied to the primary file
7 system, using the first snapshot copy to restore the primary file system to the state of the
8 secondary file system existing when read/write access of the secondary file system was
9 begun, and then writing into the primary file system the changes made to the secondary
10 file system during the read/write access to the secondary file system between the time of
11 the first snapshot copy and the second snapshot copy; and

12 terminating read/write access to the secondary file system, and once the changes
13 made to the secondary file system have been written into the primary file system,
14 restarting the read/write access to the primary file system and asynchronous remote copy
15 of changes made to the primary file system being copied to the secondary file system.

16
17 9. The method as claimed in claim 8, wherein the asynchronous remote copy
18 of changes made to the primary file system being copied to the secondary file system
19 includes using the Internet Protocol to transmit the changes made to the primary file
20 system over a data network between the primary site and the secondary site.

21
22 10. The method as claimed in claim 8, wherein the asynchronous remote copy
23 of changes made to the secondary file system since the second snapshot copy being

1 copied to the primary file system includes transmitting changes made to the secondary
2 file system over a first IP pipe from the secondary site to the primary site, and which
3 further includes transmitting changes made to the secondary file system between the first
4 snapshot copy and the second snapshot copy over a second IP pipe from the secondary
5 site to the primary site, and wherein the transmission of the changes made to the
6 secondary file system over the first IP pipe is concurrent with the transmission of the
7 changes made to the secondary file system over the second IP pipe.

8
9 11. In an asynchronous remote copy system in which changes made to data
10 blocks of a primary file system at a primary site are transmitted to a secondary file system
11 at a secondary site, the primary site storing a list of the data blocks that have been changed
12 in the primary file system, a method of recovery from a disruption at the primary site,
13 said method comprising:

14 accessing the list of the data blocks that have been changed in the primary file
15 system to restore the primary file system to a prior state at a restart point, the prior state at
16 the restart point including changes made to the primary file system that have been
17 transmitted to the secondary site, the primary file system being restored by determining
18 from the list the data blocks that have been changed in the primary file system since the
19 restart point, and obtaining from the secondary site the data existing at the time of the
20 restart point in the data blocks that have been changed in the primary file system since the
21 restart point, and writing into the primary file system the data existing at the time of the
22 restart point in the data blocks that have been changed in the primary file system since the
23 restart point.

1
2 12. The method as claimed in claim 11, which includes the secondary site
3 responding to the disruption by making a snapshot copy of the secondary file system at
4 the restart point once all of the changes to the primary file system that have been
5 transmitted to the secondary file system have been written into the secondary file system,
6 and wherein the data existing at the time of the restart point in the data blocks that have
7 been changed in the primary file system since the restart point are obtained from the
8 snapshot copy at secondary site.

9
10 13. The method as claimed in claim 11, which further includes the secondary
11 site activating the secondary file system for read/write access once all of the changes to
12 the primary file system that have been transmitted to the secondary file system prior to
13 the disruption have been written into the secondary file system.

14
15 14. The method as claimed in claim 11, which further includes the secondary
16 site responding to the disruption by activating the secondary file system for read/write
17 access, and wherein the state of the primary file system at the restart point is the state of
18 the secondary file system when the secondary file system is activated for read/write
19 access.

20
21 15. The method as claimed in claim 14, which includes the secondary site
22 keeping a record of changes made to the secondary file system since the restart point, and
23 once the primary site is operative and after writing into the primary file system the data

1 existing at the time of the restart point in the data blocks that have been changed in the
2 primary file system since the restart point, writing the changes made to the secondary file
3 system since the restart point into the primary file system.
4

5 16. The method as claimed in claim 14, which includes the secondary site
6 keeping a record of changes made to the secondary file system since the restart point, and
7 once the primary site is operative, beginning at an intermediate point replication of
8 changes made to the secondary file system, and after writing into the primary file system
9 the data existing at the time of the restart point in the data blocks that have been changed
10 in the primary file system since the restart point, copying changes made to the secondary
11 file system since the restart point and up to the intermediate point into the primary file
12 system.
13

14 17. The method as claimed in claim 16, which includes beginning playback of
15 the replicated changes made to the secondary file system into the primary file system
16 once the changes made to the secondary file system since the restart point and up to the
17 intermediate point have been copied to the primary file system.
18

19 18. The method as claimed in claim 17, which includes ending read/write
20 access to the secondary file system thereby terminating the replication of changes made
21 to the secondary file system, and once all of the changes made to the secondary file
22 system have been played back into the primary file system, the primary site restarts the

1 transmission of changes made to data blocks of the primary file system to the secondary
2 file system.

3
4 19. An asynchronous remote copy system comprising a primary data storage
5 system and a secondary data storage system, the primary data storage system having a
6 primary file system and the secondary data storage system having a secondary file
7 system, the primary data storage system being programmed for read/write access to the
8 primary file system and asynchronous remote copy of changes made to the primary file
9 system being copied to the secondary file system,

10 wherein the secondary data storage system is programmed to respond to the
11 primary data storage system becoming inoperative during the asynchronous remote copy
12 of changes made to the primary file system being copied to the secondary file system by
13 beginning read/write access to the secondary file system, making a snapshot copy of the
14 secondary file system at the beginning of read/write access to the secondary file system,
15 and keeping a record of changes made to the secondary file system during the read/write
16 access to the secondary file system; and

17 wherein the primary data storage system and the secondary data storage system
18 are programmed for recovery when the primary data storage system becomes operative
19 by using the snapshot copy to restore the primary file system to the state of the secondary
20 file system existing when read/write access of the secondary file system was begun, and
21 then writing into the primary file system the changes made to the secondary file system
22 during the read/write access to the secondary file system, terminating read/write access to
23 the secondary file system, and once the changes made to the secondary file system have

1 been written into the primary file system, restarting read/write access to the primary file
2 system and asynchronous remote copy of changes made to the primary file system being
3 copied to the secondary file system.
4

5 20. The asynchronous remote copy system as claimed in claim 19, wherein the
6 primary data storage system is programmed to perform the asynchronous remote copy of
7 changes made to the primary file system being copied to the secondary file system by
8 using the Internet Protocol to transmit the changes made to the primary file system over a
9 data network between the primary data storage system and the secondary data storage
10 system.
11

12 21. The asynchronous remote copy system as claimed in claim 20, wherein the
13 secondary data storage system is programmed to respond to the primary data storage
14 system becoming operative by transmitting over a first IP pipe changes having been made
15 to the secondary file system during the read/write access to the secondary file system
16 prior to the primary data storage system becoming operative, and concurrently
17 transmitting over a second IP pipe changes having been made to the secondary file
18 system during read/write access to the secondary file system after the primary data
19 storage system becomes operative.
20

21 22. The asynchronous remote copy system as claimed in claim 19, wherein the
22 state of the secondary file system existing when read/write access of the secondary file
23 system was begun is a prior state of the primary file system existing before the primary

1 data storage system became inoperative, and wherein the primary data storage system is
2 programmed to keep a list of blocks that have been changed in the primary file system
3 during the read/write access to the primary file system, and to restore the primary file
4 system to the state of the secondary file system existing when read/write access of the
5 secondary file system was begun by accessing the list of blocks that have been changed
6 in the primary file system during the read/write access to the primary file system to
7 determine the blocks that have been changed in the primary file system since said prior
8 state of the primary file system, and copying from the snapshot copy to the primary file
9 system the blocks that have been changed in the primary file system since said prior state
10 of the primary file system.

11
12 23. An asynchronous remote copy system comprising a primary data storage
13 system and a secondary data storage system, the primary data storage system having a
14 primary file system and the secondary data storage system having a secondary file
15 system, the primary data storage system being programmed for read/write access to the
16 primary file system and asynchronous remote copy of changes made to the primary file
17 system being copied to the secondary file system,

18 wherein the secondary data storage system is programmed to respond to the
19 primary data storage system becoming inoperative during the asynchronous remote copy
20 of changes made to the primary file system being copied to the secondary file system by
21 the secondary data storage system beginning read/write access to the secondary file
22 system, and

1 wherein the primary data storage system and the secondary data storage system
2 are programmed to respond to the primary data storage system becoming operative by
3 synchronizing the primary file system to the secondary file system by beginning
4 asynchronous remote copy of changes made to the secondary file system being copied to
5 the primary file system, making a snapshot copy of the secondary file system at the
6 beginning of the asynchronous remote copy of changes made to the secondary file system
7 being copied to the primary file system, synchronizing the primary file system to the
8 snapshot copy of the secondary file system, and once the primary file system has been
9 synchronized to the snapshot copy of the secondary file system, terminating read/write
10 access to the secondary file system and completing the asynchronous remote copy of
11 changes made to the secondary file system being copied to the primary file system; and
12 once the asynchronous remote copy of changes made to the secondary file system has
13 been completed, restarting read/write access to the primary file system and asynchronous
14 remote copy of changes made to the primary file system being copied to the secondary
15 file system.

16
17 24. The asynchronous remote copy system as claimed in claim 23, wherein the
18 primary data storage system is programmed to perform the asynchronous remote copy of
19 changes made to the primary file system being copied to the secondary file system by
20 using the Internet Protocol to transmit the changes made to the primary file system over a
21 data network between the primary data storage system and the secondary data storage
22 system.

1 25. The asynchronous remote copy system as claimed in claim 23, wherein the
2 secondary data storage system is programmed to perform the asynchronous remote copy
3 of changes made to the secondary file system being copied to the primary file system by
4 transmitting changes made to the secondary file system over a first IP pipe from the
5 secondary data storage system to the primary data storage system, and the secondary data
6 storage system is programmed to synchronize the primary file system to the snapshot
7 copy of the secondary file system by transmitting changes made to the secondary file
8 system over a second IP pipe from the secondary data storage system to the primary data
9 storage system, wherein the transmission of the changes made to the secondary file
10 system over the first IP pipe is concurrent with the transmission of the changes made to
11 the secondary file system over the second IP pipe.

12
13 26. An asynchronous remote copy system comprising a primary data storage
14 system and a secondary data storage system, the primary data storage system having a
15 primary file system and the secondary data storage system having a secondary file
16 system, the primary data storage system being programmed for read/write access to the
17 primary file system and asynchronous remote copy of changes made to the primary file
18 system being copied to the secondary file system,

19 wherein the secondary data storage system is programmed to respond to the
20 primary data storage system becoming inoperative during the asynchronous remote copy
21 of changes made to the primary file system being copied to the secondary file system by
22 beginning read/write access to the secondary file system, making a first snapshot copy of
23 the secondary file system at the beginning of read/write access to the secondary file

1 system, and keeping a record of changes made to the secondary file system during the
2 read/write access to the secondary file system;

3 wherein the secondary data storage system is programmed to respond to the
4 primary data storage system becoming operative by making a second snapshot copy of
5 the secondary file system, and beginning asynchronous remote copy of changes made to
6 the secondary file system since the second snapshot copy being copied to the primary file
7 system; and

8 wherein the primary data storage system and the secondary data storage system
9 are programmed for using the first snapshot copy to restore the primary file system to the
10 state of the secondary file system existing when read/write access of the secondary file
11 system was begun, and then writing into the primary file system the changes made to the
12 secondary file system during the read/write access to the secondary file system between
13 the time of the first snapshot copy and the second snapshot copy, and terminating
14 read/write access to the secondary file system, and once the changes made to the
15 secondary file system have been written into the primary file system, restarting read/write
16 access to the primary file system and asynchronous remote copy of changes made to the
17 primary file system being copied to the secondary file system.

18
19 27. The asynchronous remote copy system as claimed in claim 26, wherein the
20 primary data storage system is programmed to perform the asynchronous remote copy of
21 changes made to the primary file system being copied to the secondary file system by
22 using the Internet Protocol to transmit the changes made to the primary file system over a

1 data network between the primary data storage system and the secondary data storage
2 system.

3
4 28. The asynchronous remote copy system as claimed in claim 26, wherein the
5 secondary data storage system is programmed to perform the asynchronous remote copy
6 of changes made to the secondary file system since the second snapshot copy being
7 copied to the primary file system by transmitting changes made to the secondary file
8 system since the second snapshot copy over a first IP pipe from the secondary data
9 storage system to the primary data storage system, and the secondary data storage system
10 is programmed to transmit the changes made to the secondary file system during the
11 read/write access to the secondary file system between the time of the first snapshot copy
12 and the second snapshot copy over a second IP pipe from the secondary data storage
13 system to the primary data storage system, wherein the transmission of the changes made
14 to the secondary file system over the first IP pipe is concurrent with the transmission of
15 the changes made to the secondary file system over the second IP pipe.

16
17 29. An asynchronous remote copy system comprising a primary data storage
18 system and a secondary data storage system, the primary data storage system having a
19 primary file system and the secondary data storage system having a secondary file
20 system, the primary data storage system being programmed for read/write access to the
21 primary file system and asynchronous remote copy of changes made to the primary file
22 system being copied to the secondary file system, the primary data storage system storing
23 a list of the data blocks that have been changed in the primary file system;

1 wherein the primary data storage system and the secondary data storage system
2 are programmed for recovering from a disruption in the asynchronous remote copy of
3 changes made to the primary file system being copied to the secondary file system by
4 accessing the list of the data blocks that have been changed in the primary file system to
5 restore the primary file system to a prior state at a restart point, the prior state at the
6 restart point including changes made to the primary file system that have been
7 transmitted to the secondary data storage system, the primary file system being restored
8 by determining from the list the data blocks that have been changed in the primary file
9 system since the restart point, and obtaining from the secondary data storage system the
10 data existing at the time of the restart point in the data blocks that have been changed in
11 the primary file system since the restart point, and writing into the primary file system the
12 data existing at the time of the restart point in the data blocks that have been changed in
13 the primary file system since the restart point.

14
15 30. The asynchronous remote copy system as claimed in claim 29, wherein the
16 secondary data storage system is programmed to respond to the disruption by making a
17 snapshot copy of the secondary file system at the restart point once all of the changes to
18 the primary file system that have been transmitted to the secondary file system have been
19 written into the secondary file system, and wherein the secondary file system is
20 programmed to obtain from the snapshot copy the data existing at the time of the restart
21 point in the data blocks that have been changed in the primary file system since the restart
22 point.

1 31. The asynchronous remote copy system as claimed in claim 29, wherein the
2 secondary data storage system is programmed to activate the secondary file system for
3 read/write access once all of the changes to the primary file system that have been
4 transmitted to the secondary file system prior to the disruption have been written into the
5 secondary file system.

6
7 32. The asynchronous remote copy system as claimed in claim 29, wherein the
8 secondary data storage system is programmed to respond to the disruption by activating
9 the secondary file system for read/write access, and the state of the primary file system at
10 the restart point is the state of the secondary file system when the secondary file system is
11 activated for read/write access.

12
13 33. The asynchronous remote copy system as claimed in claim 32, wherein the
14 secondary data storage system is programmed for keeping a record of changes made to
15 the secondary file system since the restart point, and wherein the primary data storage
16 system is programmed for writing into the primary file system the data existing at the
17 time of the restart point in the data blocks that have been changed in the primary file
18 system since the restart point and then writing the changes made to the secondary file
19 system since the restart point into the primary file system.

20
21 34. The asynchronous remote copy system as claimed in claim 32, wherein the
22 secondary data storage system is programmed for keeping a record of changes made to
23 the secondary file system since the restart point, and for responding to the primary data

1 storage system becoming operative after the disruption by beginning at an intermediate
2 point replication of changes made to the secondary file system, and copying to the
3 primary data storage system changes made to the secondary file system since the restart
4 point and up to the intermediate point.

5
6 35. The asynchronous remote copy system as claimed in claim 34, wherein the
7 primary data storage system is programmed to write into the primary file system the
8 changes made to the secondary file system since the restart point and up to the
9 intermediate point, and then begin playback of the replicated changes made to the
10 secondary file system into the primary file system.

11
12 36. The asynchronous remote copy system as claimed in claim 35, wherein the
13 primary data storage system is programmed to restart read/write access to the primary file
14 system and asynchronous remote copy of changes made to the primary file system being
15 copied to the secondary data storage system once all of the changes made to the
16 secondary file system have been played back into the primary file system.